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DEVELOPMENT OF AUDITORY LOCALIZATION
TEST PROCEDURE

Annual/Final Report

December 1984

William R. Howse and Lloyd F. Elfner

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Abstract

A stimulus identification procedure using a single stimulus transducer on a rotating boom was compared with a previous effort using multiple transducers. The single transducer approach eliminates speaker signature cues and provides greater angular-resolution than multiple spatially fixed transducers. Signals were long duration broad band noise bursts presented randomly from 36 equally spaced azimuths. Localization with no hearing protector was more accurate than in the multiple transducer study. Hearing protectors, both passive and active were shown to severly disturb auditory localization ability. Active hearing protectors effectively eliminated localization ability.

A stimulus discrimination study using the above apparatus demonstrated that discrimination of source disparity was best for 0° azimuth and poorest for azimuths of 135° and 225°.

Free field Localization With a Single Sound Transducer

FOREWORD

For the protection of human subjects the investigator(s) have adhered to policies of applicable Federal Law 45CFR46.

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INTRODUCTION

The research reported was carried out as part of a contract between Florida State University and the U.S. Army Medical Research and Development Command to develop a system for rapid assessement of human auditory localization ability as affected by various hearing and ballistic protection devices. This study is a partial replication of an earlier study (Howse & Elfner, 1982) in which stimuli were presented using multiple transducers. The purposes of this study are to demonstrate the abilities of a second generation assessement system using a single transducer in a larger controlled environment and to provide initial data to use for comparison in future experiments. This second generation system eliminates extraneous cues to localization provided by differing frequency spectrum signatures of multiple transducers, and provides greatly increased angular resolution for stimulus presentation.

The same hearing protective devices tested in the multiple transducer study are considered here. The DH-178 helmet is a prototype ballistic helmet combined with circumaural hearing protection and a "talk-through" amplification of high level acoustic input. The DH-178 was two independent amplification circuits, one for each ear. It therefore provides a dichotic signal to the wearer. The DH-140 is also a ballistic helmet similar to the DH-178. The most important difference is that the DH-14- uses a single amplification circuit distributed to the two ears. It provides a diotic signal to the wearer.

Method

Subjects:

Three paid volunteers ages 19, 24, and 33, served as observers. One of the subjects was male and two were female. All three subjects had pure tone auditory thresholds within normal limits (ANSI, 1969) at audiometric frequencies and also exhibited thresholds at no greater than 20 db (re: 20 uPa) at 10kHz. Subjects had no known auditory or vestibular pathologies. Two of the subjects had normal far-field visual acuity and one wore corrective lenses. One of the subjects had served in the previous localization study.

Apparatus:

Observations were made in a Tracoustics, Inc. anechoic chamber which had an internal free space measuring 23 ft. by 17 ft. by 17 1/2 ft. The response manipulandum was the same as described in the previous study, was the chair. These were mounted on a frame which was adjustable in two directions of the horizontal plane to achieve centering of the subject's head. The mounted chair is shown in Figure 1. A rotatable boom centered over the observer's head carried stimulus and masking transducers. The boom had a radius of 8 ft. and could be rotated to any angle in less than two seconds. Error of angular placement was less than 1/2 degree. An observer viewing of the boom is shown in Figure 2.

The transducers were Koss ESP-10 electrostatic units, one mounted on the end of the boom to produce the experimental stimuli and one mounted at the center of the boom, directly over the observer's head to produce masking noise. Although boom movement noise was minimal the residual noise was audible to subjects when not wearing hearing protective devices. Since this could have provided a temporal cue to the extent of excursion of the boom on a given trial, the masker was used to obscure that cue in all conditions. The auditory signal was a 750 ms burst of broad band noise delivered through the boom-mounted speaker with 10 ms rise/fall times. This speaker was fitted with a back baffle to smooth the frequency response curve and increase the proportion of forward to backward radiated energy. Stimuli were presented at a level of 54 dB (re = 20 uPa) measured at the observer's head position without an observer in place. A typical amplitude spectrum of the stimulus at the observer's head position is shown in Figure 3. The position of the boom-mounted speaker was adjustable vertically to effect alignment with the observers interaural axis. The coupling network of the center mounted speaker was altered and a back baffle was not used so that a frequency response spectrum distinct from that of the experimental stimulus would be produced. An amplitude spectrum of the masker measured at the observer's head position is shown in Figure 3. The masker was presented at a level of 73 dB (re = 20 uPa) at the observer's head.

The observer's head orientation was maintained during experimental sessions through a secondary visual task. The subject wore glasses on which were mounted a small (0.5 in.^{2})

rectangular half-silvered mirror in front of the left lens. Light emitting diodes (LED) were mounted in front of the subject approximately 11 1/2 ft. away and to the left of the subject approximately 8 1/2 ft. away. The helf-silvered mirror acted to present both images in front of the subject. The LEDs were spatially adjusted so that their images coincided when the subject's head was properly oriented. Two subjects who had normal visual acuity were fitted with plain lenses, the third subject wore his own corrective lenses.

Stimulus presentation, boom rotation and response recording were carried out using a Gen Rad System 1501 FFT which is based on a DEC pdp 11/34 computer. A Bruel and Kjaer pink noise generator was the signal source. Gating was accomplished through a locally developed high speed programmable attenuator. The rotatable boom and its controller were constructed in the Florida State University Psychology Department shops.

Procedure:

All subjects were given pre-training in the experimental task without hearing protectors and using reference azimuths not included in the experimental paradigm. Practice consisted of 100 to 200 trials per subject. Prior to participating in any practice sessions a subject was given a pure tone audiogram and fitted in the observer's chair. The chair and boom-mounted speaker were adjusted so that the interaural axis was in the plane of the speaker rotation and centered at the center of rotation. The subject's head position was adjusted to approximate Reid's plane (defined by the inferior surface of the bony orbits and the centers of the bony external meati) with the plane of rotation. The orientation LEDs were than adjusted to coincide approximately in the center of the subject's left visual field. The subject was given instruction and practice in acquiring and maintaining coincidence of these visual targets.

Each subject made psychophysical observations under four conditions: no helmet, DH-178 helmet in passive mode, DH-178 helmet in active mode, and DH-140 in active mode. During experimental sessions, the anechoic chamber was dark except for the red light emitted from the response manipulandum and the orientation lights and a very faint glow from fluorescent paint marking the room's emergency escape panels.

A trial was initiated by the subject pressing a button on the rim of the response manipulandum. The center mounted masker speaker was gated on with a 10 ms ramp and the boom was rotated to one of 36 positions selected from an array of 180 without replacement. The masker was left on for 2.5 s and gated off with a 10 ms ramp. The maximum excursion time for the boom (for a move of 180°) was approximately 2 s. The masker was followed by a 1 s silent period. The boom-mounted speaker was then gated on with a 10 ms ramp for 750 ms and gated off with a 10 ms ramp. The observer was then required to adjust the position of the pointer on the response manipulandum to his best estimate of perceived azimuth of the stimulus and initiate the next trial by pressing the button again.

An experimental session consisted of 5 trials with each of 36 azimuths at 10° intervals for a total of 180 trials.

Each subject observed in 20 sessions under each of the four experimental conditions. The observer's primary task was to respond in a self-paced stimulus identification pradigm. The secondary task was to maintain head orientation by spatial approximation of two visual targets.

Results

Response voltages recorded from each trial were translated into azimuth angle and rounded to the nearest 10°. These response values were sorted by their associated stimulus azimuths and alotted in 36 x 36 point integer matrices, one for each observer in each of the four conditions.

Figure 5a, b, and c presents the resulting graphs of observations made by each of the three subjects in the no-helmet condition. Correspondence between stimulus and response azimuth is remarkable for each of the three subjects. There is no evidence of systematic displacement or confusion of apparent loci. A slightly greater dispersion of responses may be seen in data from subject 3 (Figure 5c) compared to the other subjects in this study. In previous identification study using multiple transducers some anomalous features indicating confusion of one stimulus azimuth with two distinct perceptual azimuths were noted in the no-helmet condition. No such anomalies are present in the data from observations made using a single stimulus transducer. There are also no clear response biases as were seen in the multiple transducer study.

Data from observations made using the DH-178 helmet in passive mode are shown in Figure 6a, b, and c. The patterns of responding produced by the three subjects under this condition are clearly distorted when compared with the no-helmet condition. The dispersion of responses appears to be somewhat greater in this condition than in the no-helmet condition for each of the subjects but more so for subject 1. In all three cases a serpentine pattern is present, although this is masked by a secondary pattern in the case of subject 1. All subjects exhibit marked disruption of localization for stimuli originating in front of the interaural axis. For subject 1 these stimuli are confused with locations to the rear of the interaural axis. For subjects 2 and 3 there is an extreme deficiency of responses in front of the interaural axis.

Similar patterns of responding resulted when the DH-178 helmet was worn in the active mode, as may be seen in Figure 7a, b, and c. For subjects 2 and 3 the deficiency of responses which assigned azimuths in front of the interaural axis is greatly increased with little increase in the dispersion of responses. For subject 1 the pattern of confusion of stimuli originating at loci to the front with apparent loci to the rear is continued. In general the range of responding is reduced in this condition.

With the use of the DH-140 helmet in active mode localization was further degraded. Data for this condition are presented in Figure 8a, b, and c. For all three subjects there was a strong tendency to assign all stimuli to azimuths directly ahead or directly behind (0 and 180°). Subjects 1 and 3 assigned some stimuli to positions to the right of center, although these assignments do not appear to be systematic.

Subjective reports from the observers agreed that with both the DH-178 and DH-140 hlemets in active mode stimuli were perceived as being located inside the head. This internal locus varied somewhat with the DH-178 helmet but was nearly constant with the DH-140 helmet. With the DH-140 helmet subjects reported that stimuli sometimes had different qualities but did not occur in different perceived locations. For the DH-178 helmet used in passive mode subjects reported reduced sound level, as would be expected, and that the sounds were located externally. Subjects reported that the perceived locations were distinct and consistent.

Discussion

In the present study localization in the no-helmet condition was more accurate and more consistent than was observed in the prior study. This increase in localization performance is attributable to three major factors. First, the anechoic chamber used was considerably larger than the room used for the first study (over 6800 cubic feet of free space versus 1000 cubic feet) and had a lower theoretical cutoff frequency for 99% normal incidence absorption (75 Hz versus 150 Hz). It is therefore expected that reflected energy reaching the observer would have been substantially reduced in the larger room, leaving the observer to process only directly incident energy. Second, the radius of the transducer array used in the first study was 4 1/2 ft. In the currect study the radius of the ratating boom was 8 ft., providing a substantial advantage in angular resolution. Third, the spectral content of the stimulus in the present study sypplies relatively greater amounts of energy at high frequencies than were produced in the first study. The expected result would be an increase in directivity of the stimuli.

In the multiple transducer study the DH-178 and DH-140 helmets used in passive mode produced localization response patterns which indicated a 180° rotation of auditory space. In the present study the passive DH-178 helmet produced localization response patterns more indicative of a reduction of available positions in auditory space lying to in front of the interaural axis. In one of the three subjects the disturbance is more a confusion of "front" with "behind" rather than a loss of "front." It is likely that these differences between the results of the two studies stem from localization cues provided by reflections within the smaller anechoic chamber. Assuming the second study contains fewer sources for extraneous response variance, it appears that the passive hearing protector (DH-178 helmet) acts to reduce information available for localization in a systematic manner. Most stimuli seem to originate from behind the observer.

The active DH-178 helmet produced a similar pattern of responding but to a more extreme extent. The dominant pattern indicates a compression of auditory space such that few stimuli are perceived as originating from in frontof the interaural axis. The indication is that the active dichotic hearing protector further reduces information available. The response patterns seen with the DH-178 helmet, active and passive, are similar to Model 6 presented in the report of the multiple transducer study and characterized as "folded back." In this model positions in the first quadrant are translated to relative (to midline) positions in the second quadrant, and positions in the fourth quadrant are translated to the third quadrant.

The active diotic hearing protector (DH-140) leaves the observer with essentially two points in auditory space, directly in front and directly behind. This pattern is similar to the results for this helmet found in the multiple transducer study. Severe disturbance of auditory localization ability is expected with this device since complete correlation of the signals presented to the two ears removes all interaural difference cues. Since the pinnae are bypassed by this circumarual device, spectral cues should also be almost entirely eliminated. The responses of the observers likely represent arbitrary assignment of external azimuths to auditory events which fall into two catagories, possibly as a result of loudness differences resulting from the placement of a single microphone or one side of the helmt.

The dichotic device also eliminates the pinnae cues but should preserve interaural difference cues. The similarity of response patterns between the active and passive modes with the DH-178 helmet may indicate that the interaural difference cues are insufficient for localization. The difference in degree of disruption of auditory localization in these two conditions may indicate that the residual interaural difference cues are disrupted, most probably as a result of the severly distorted and narrow frequency response characteristic of the amplifiers used in the device.

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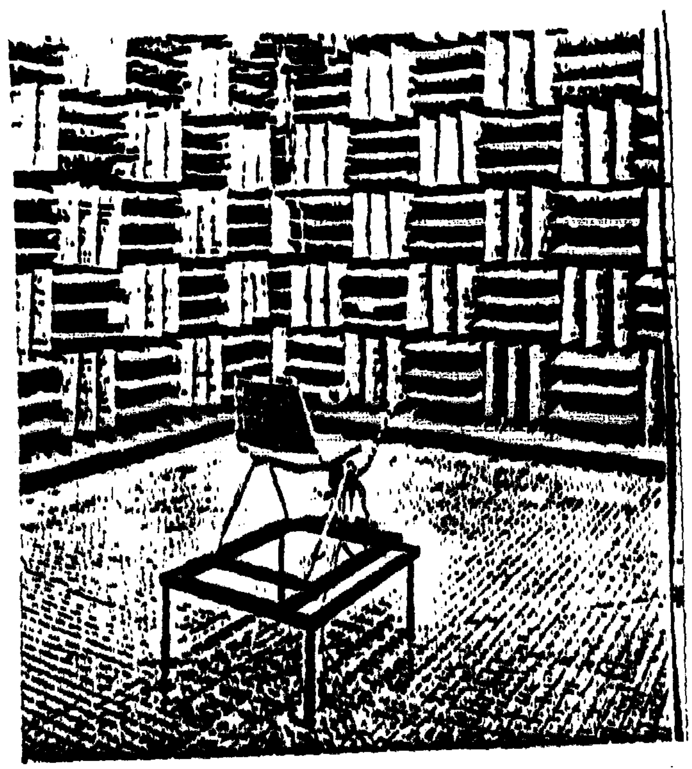
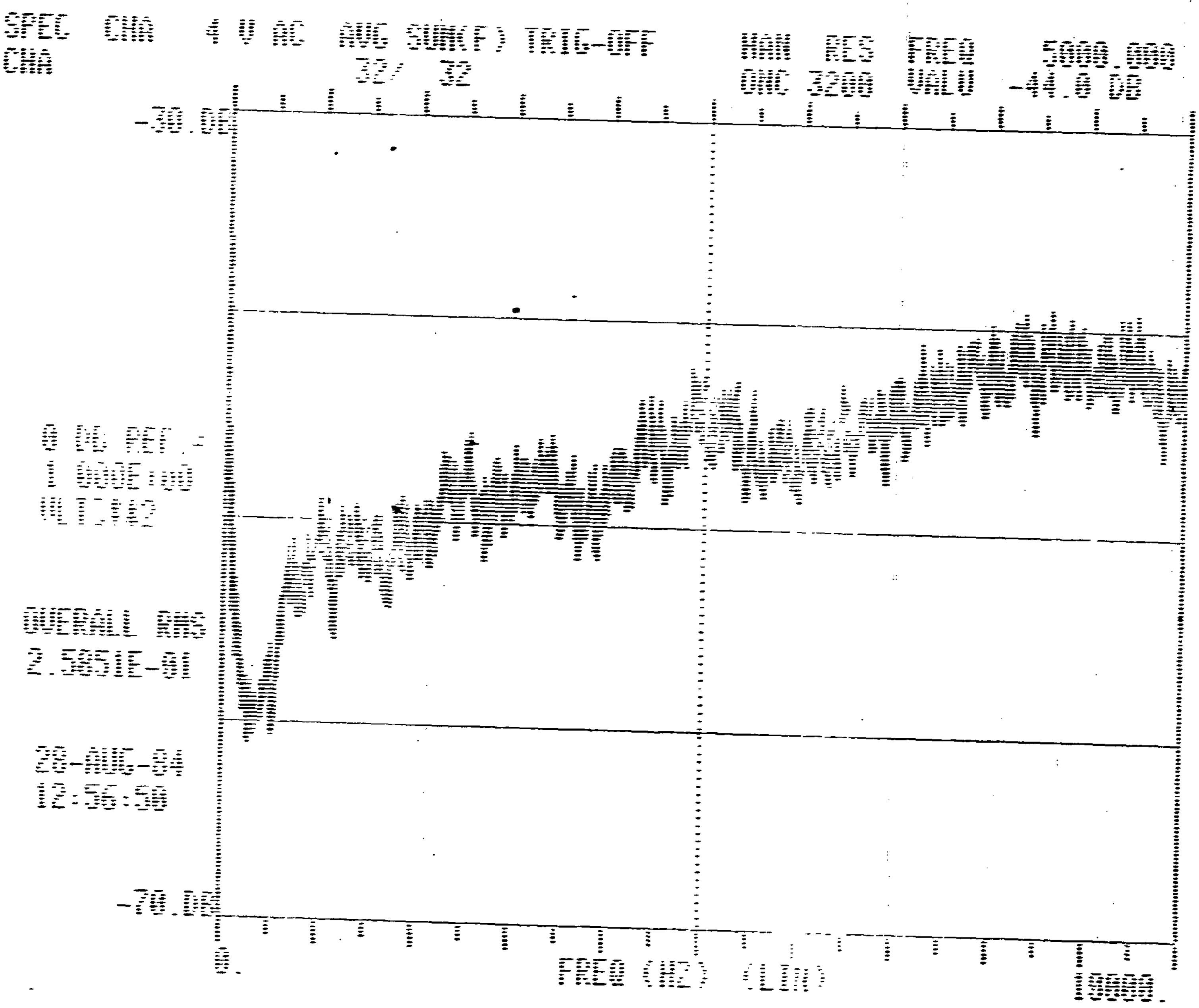
American National Standards Institute. 1969. American National Standards for Audiometers. New York: American National Standards Institute. ANSI 53.6-1969.

Howse, W.R. and Elfner, L.F. Identification of Sound Source Azimuth with Active and Passive Hearing Protectors. Interim report, U.S. Army Medical Research and Development Command project number DAMD 17-80-c-0131. September, 1982.

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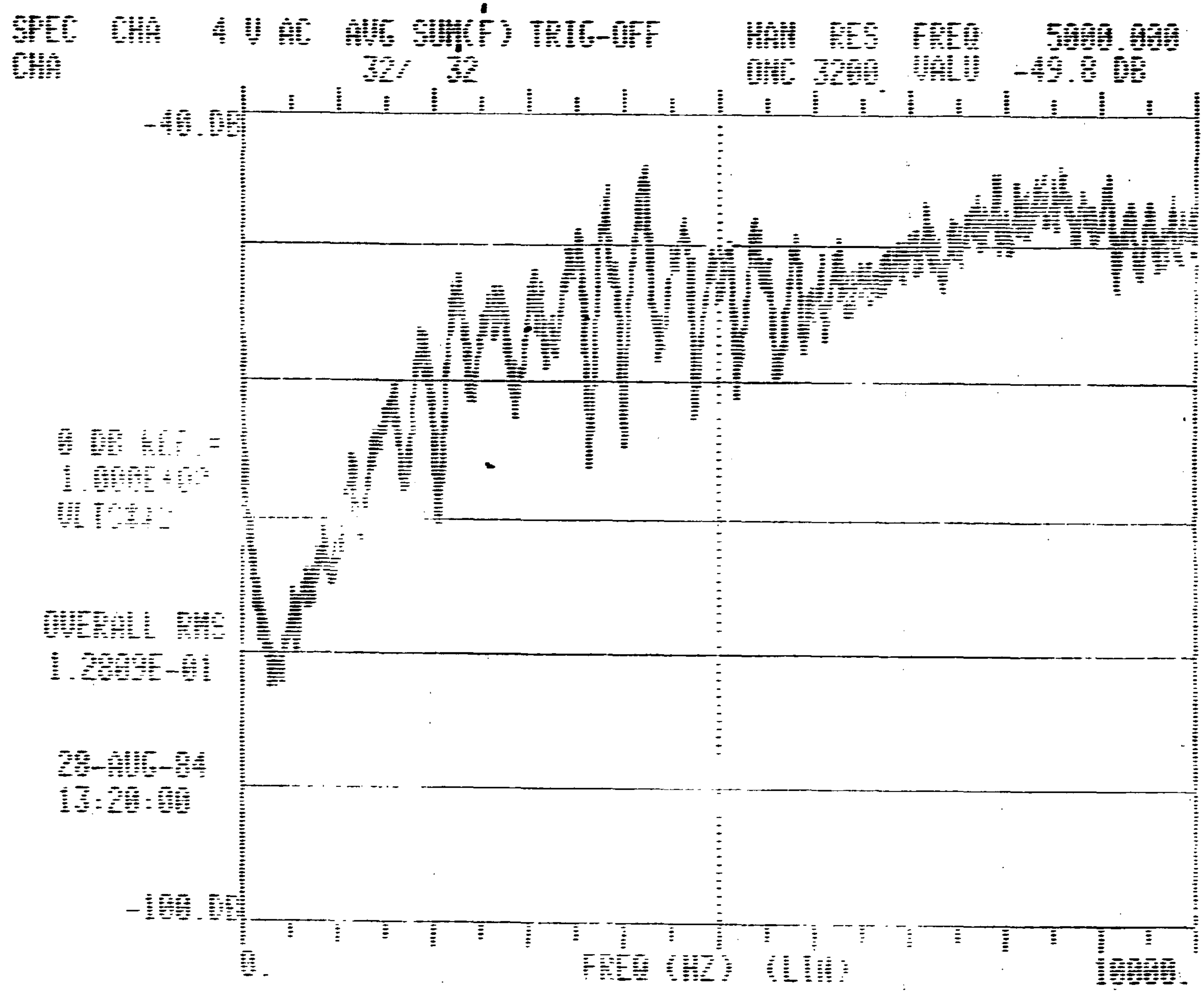
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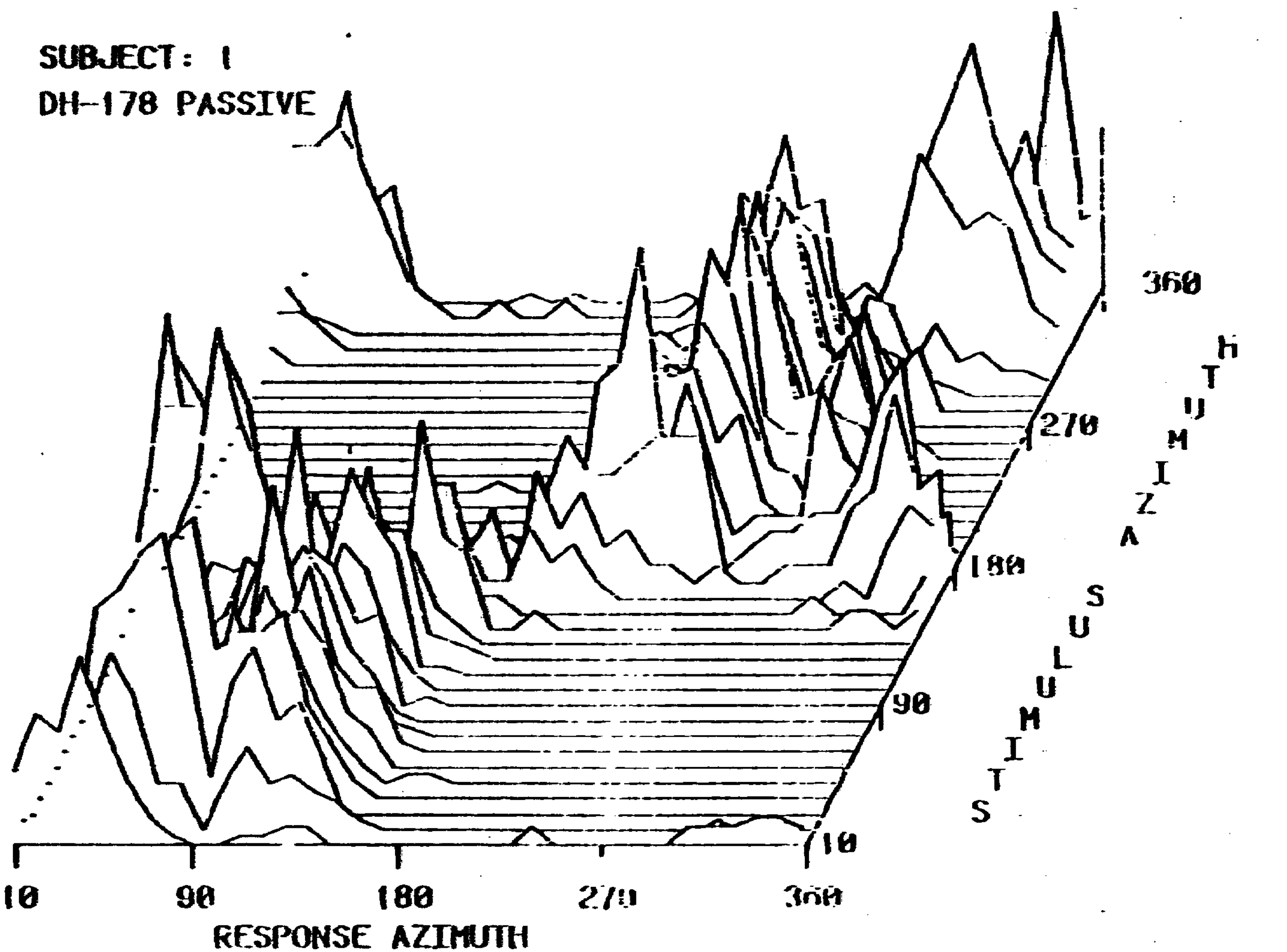
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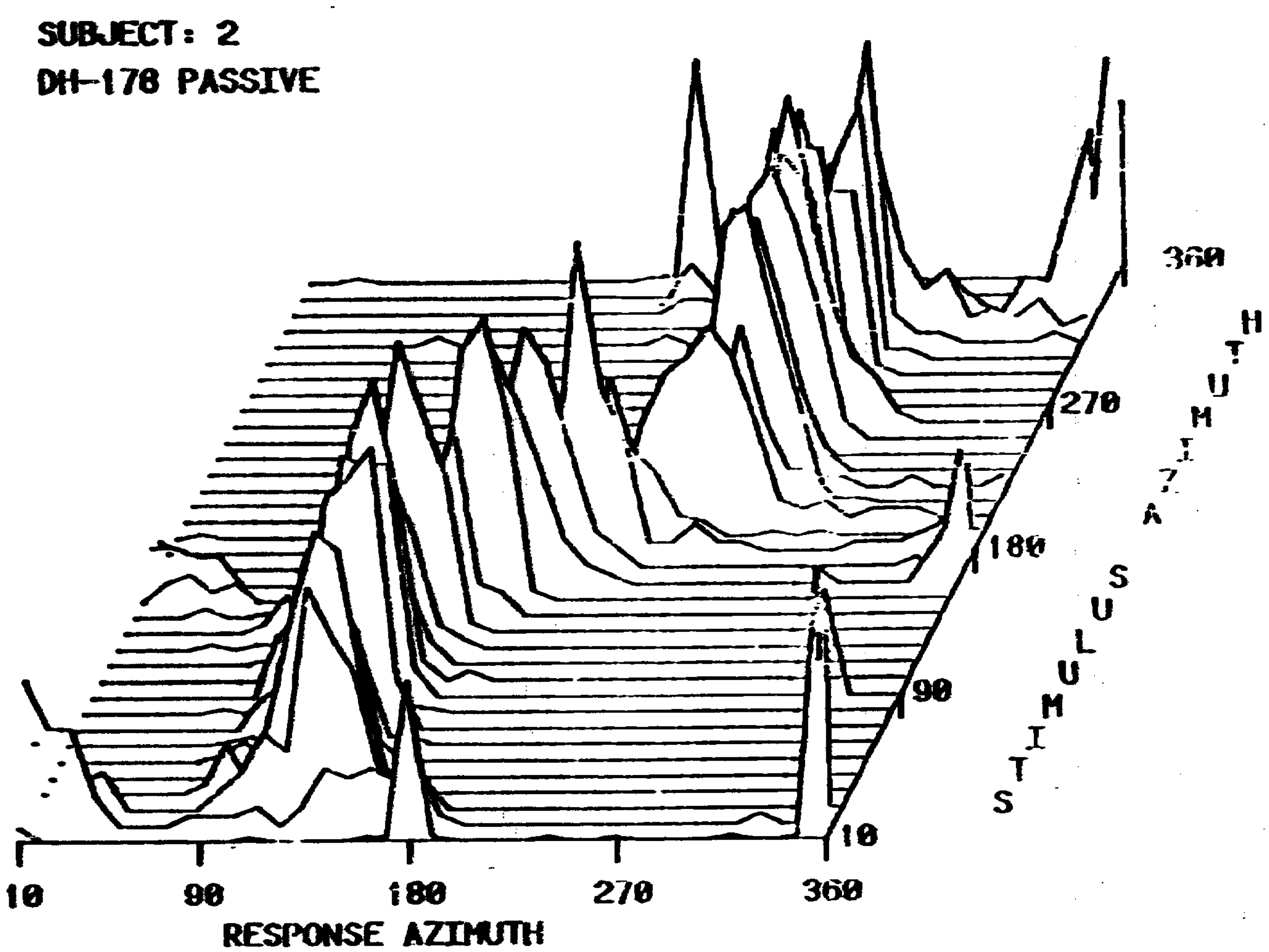
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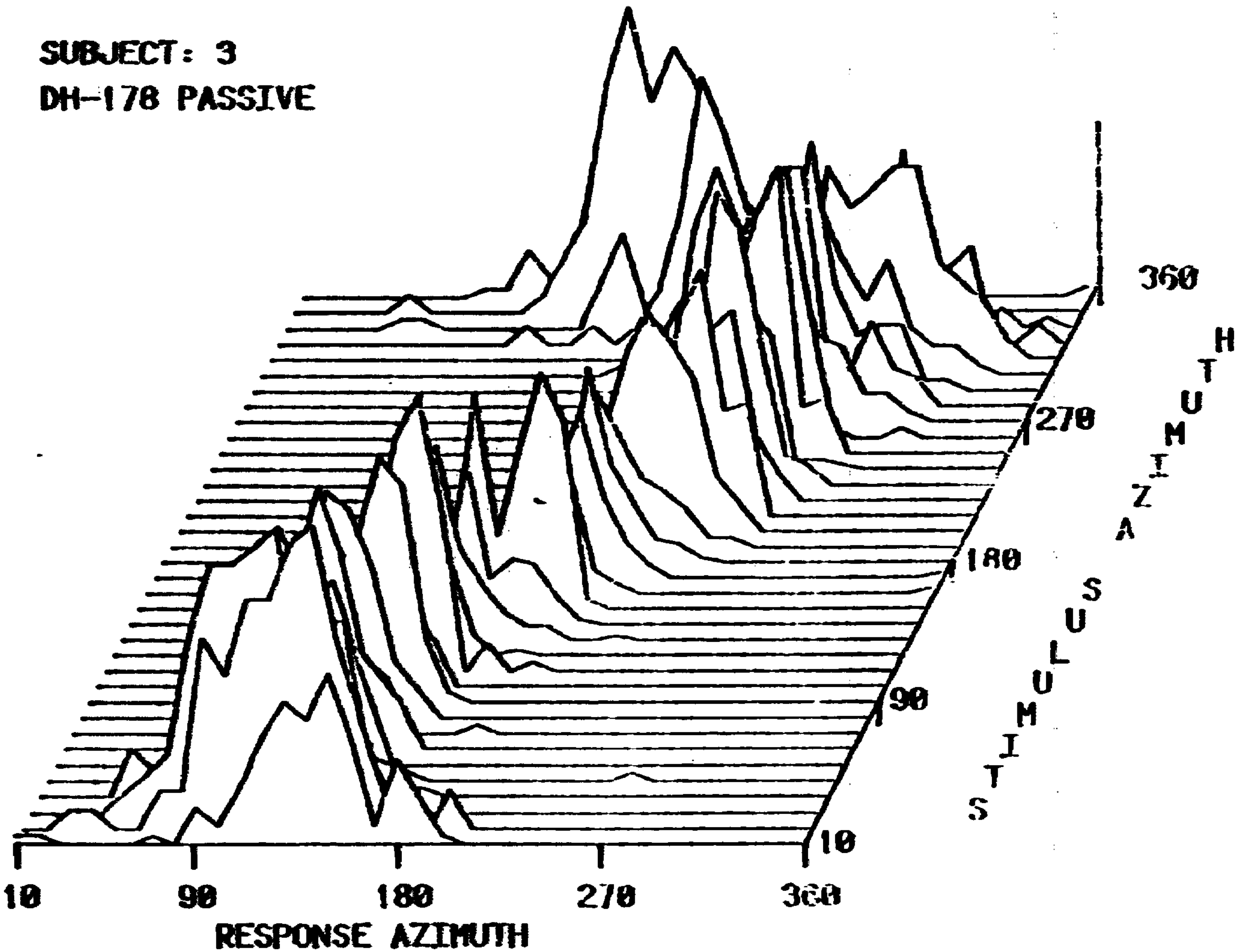
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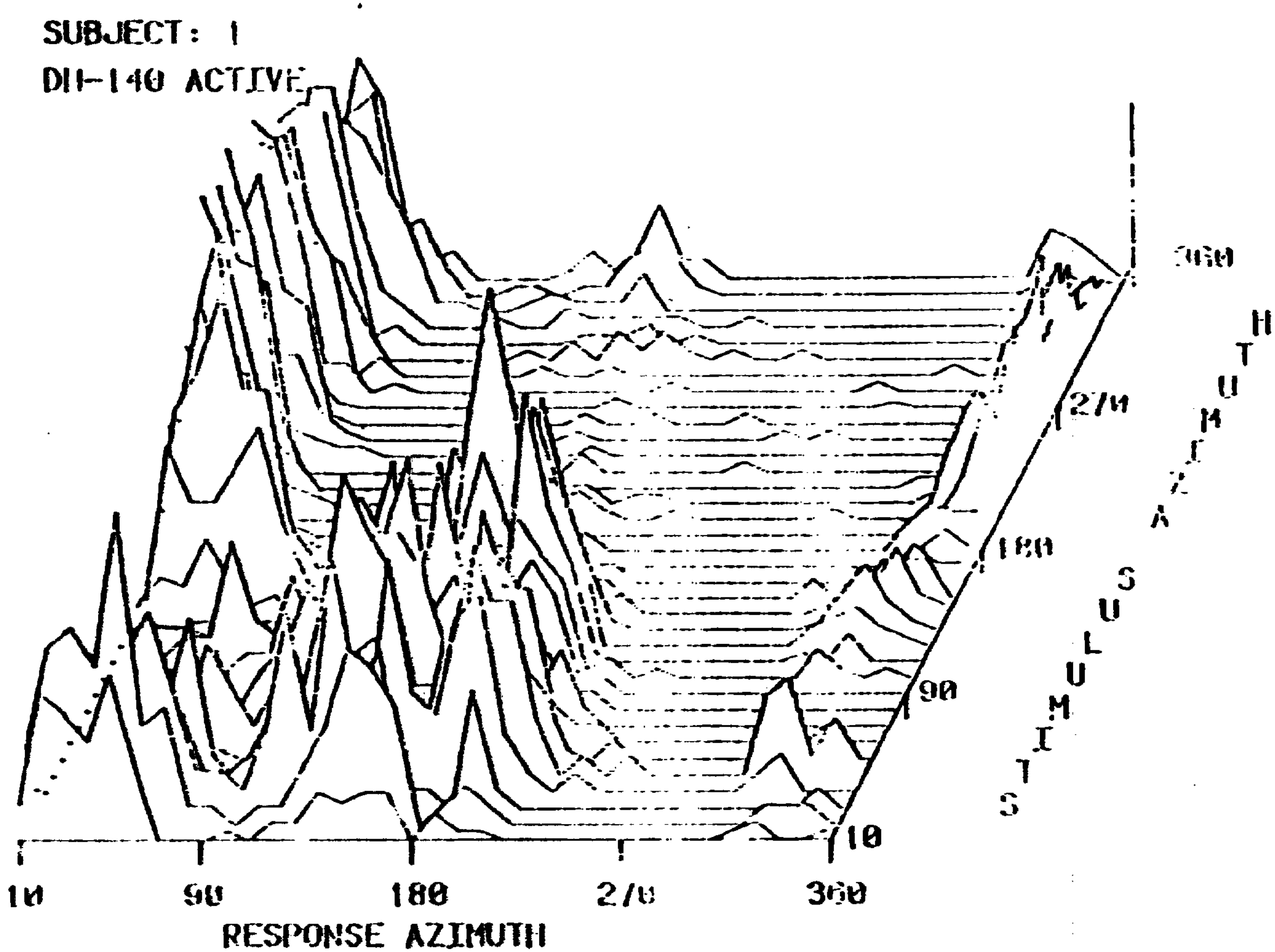

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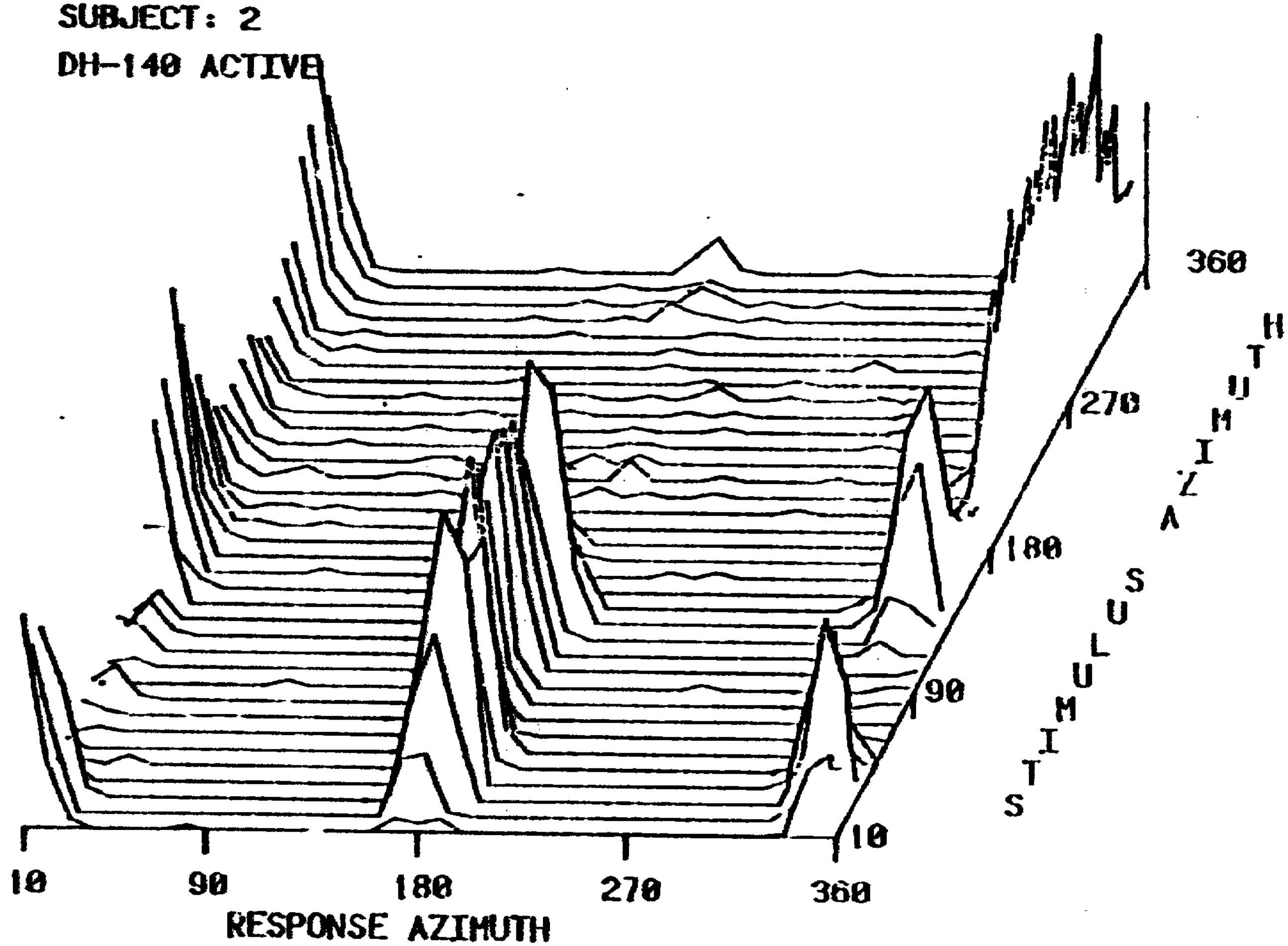
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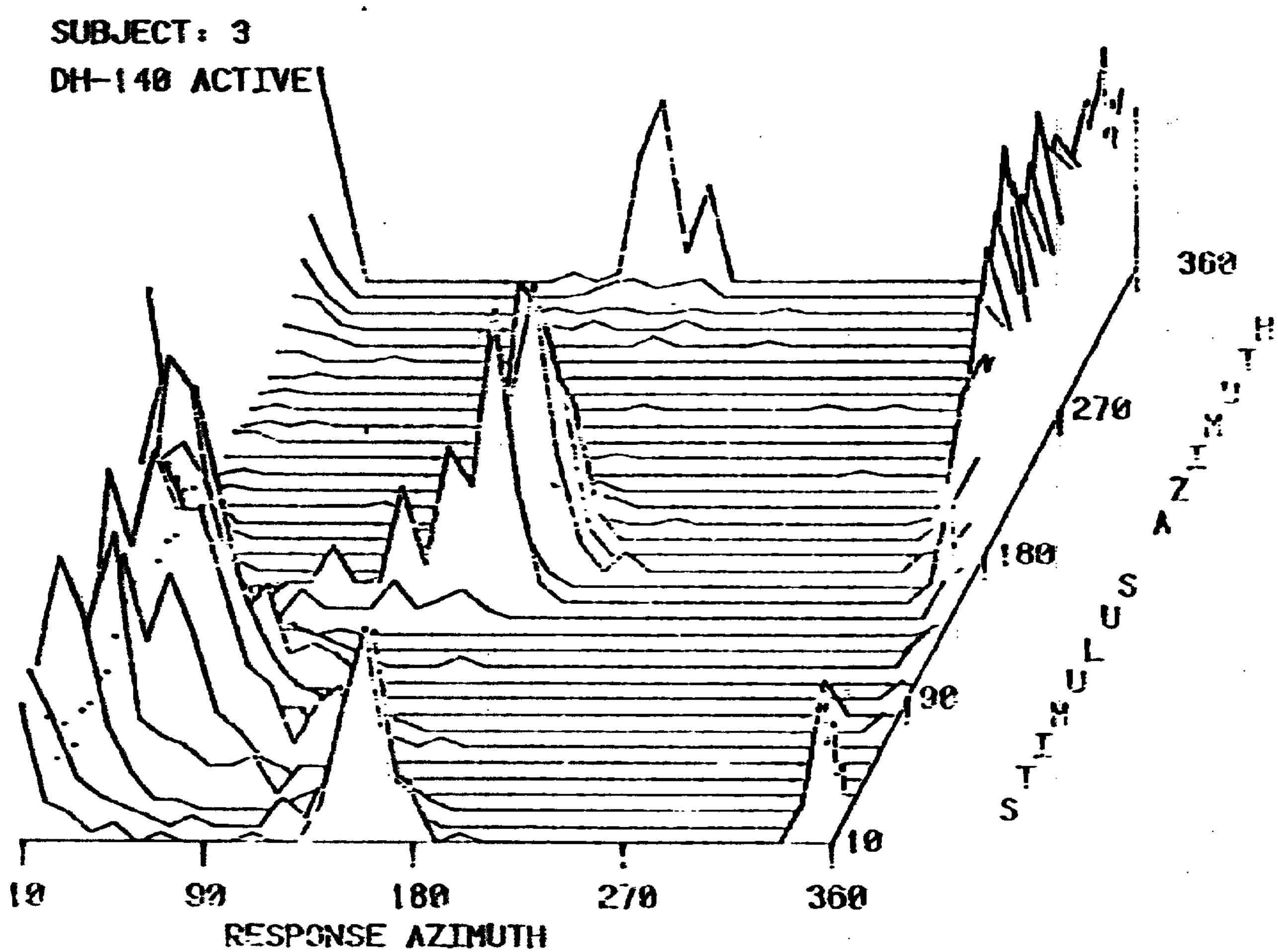
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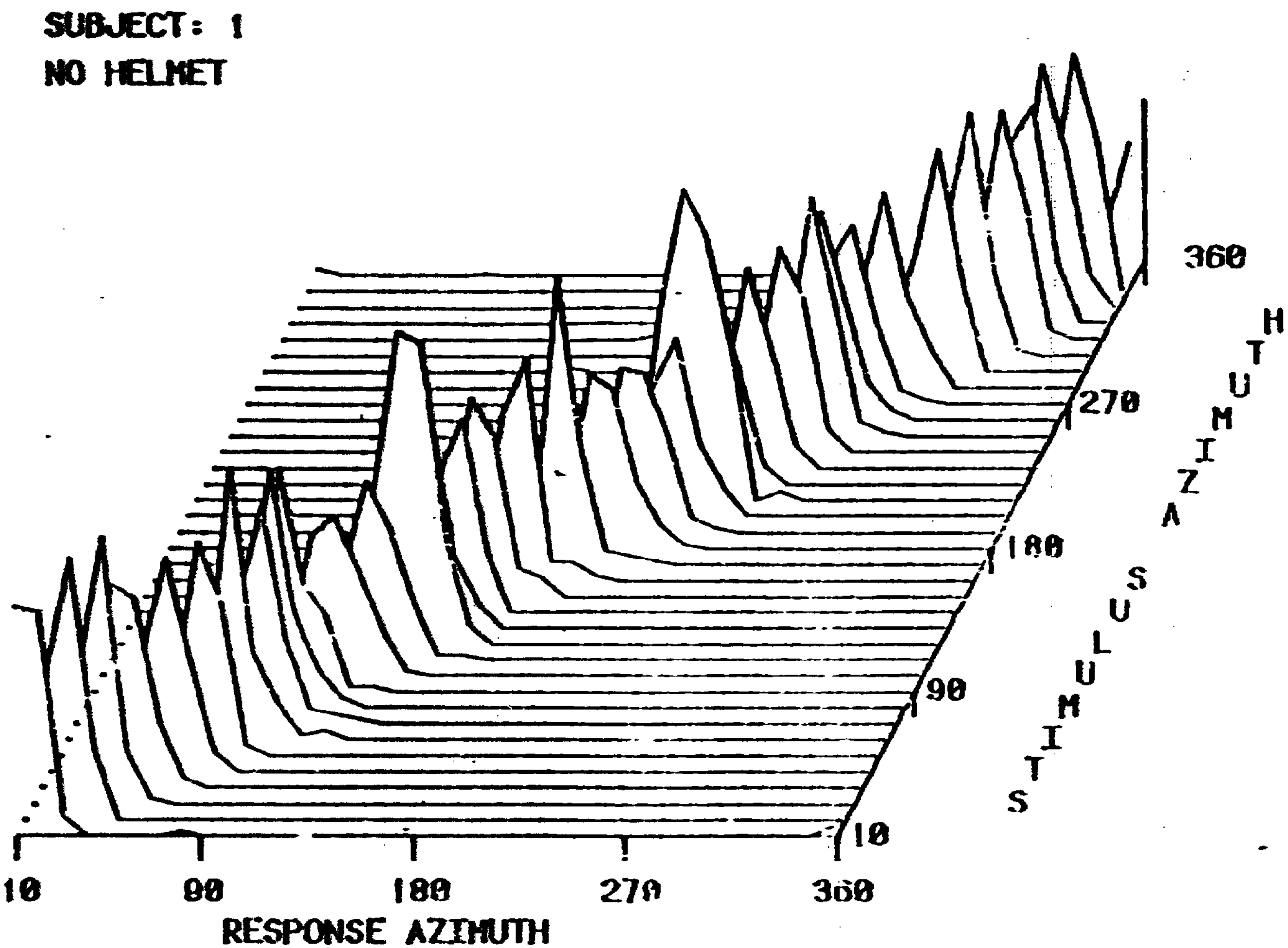

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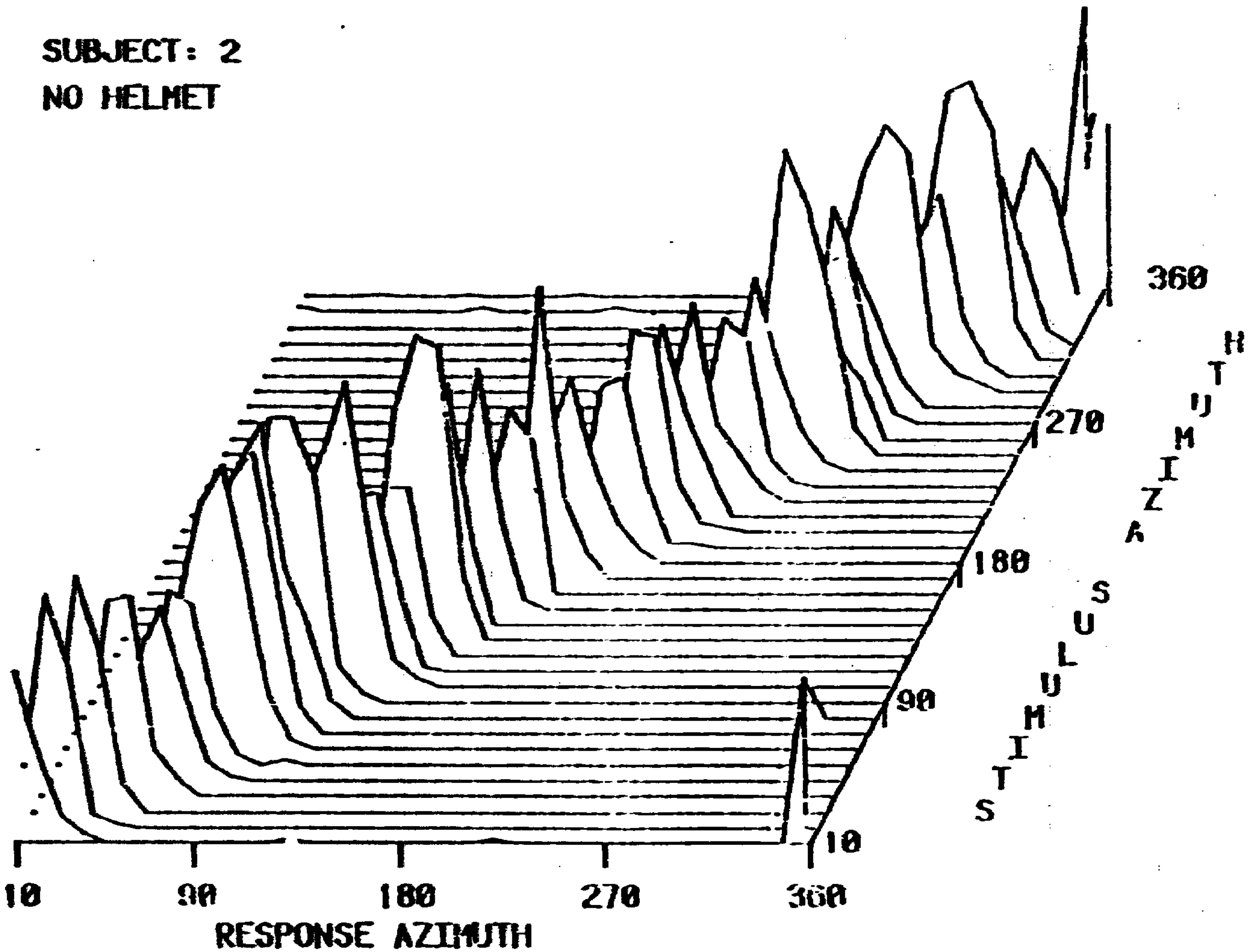
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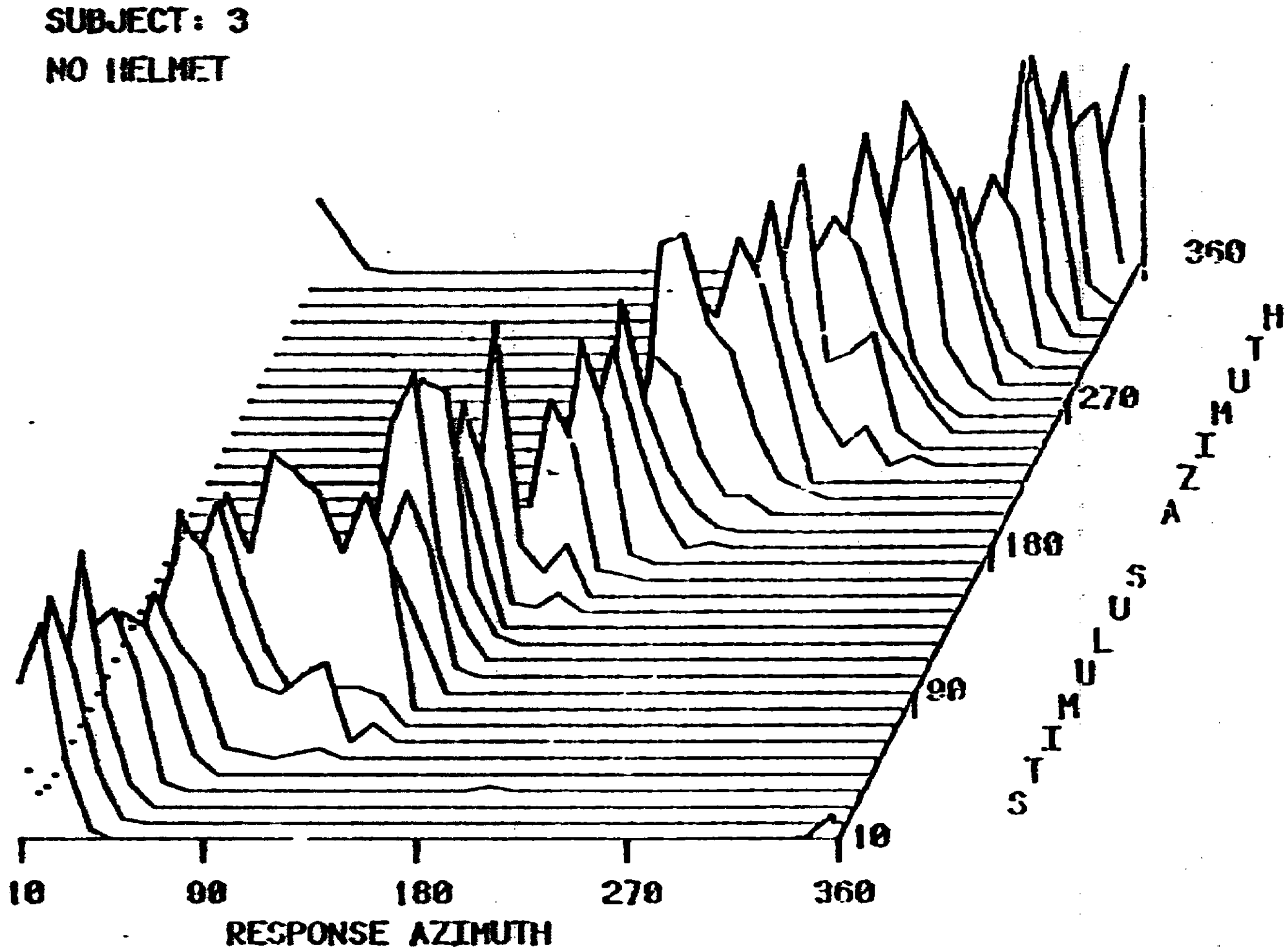

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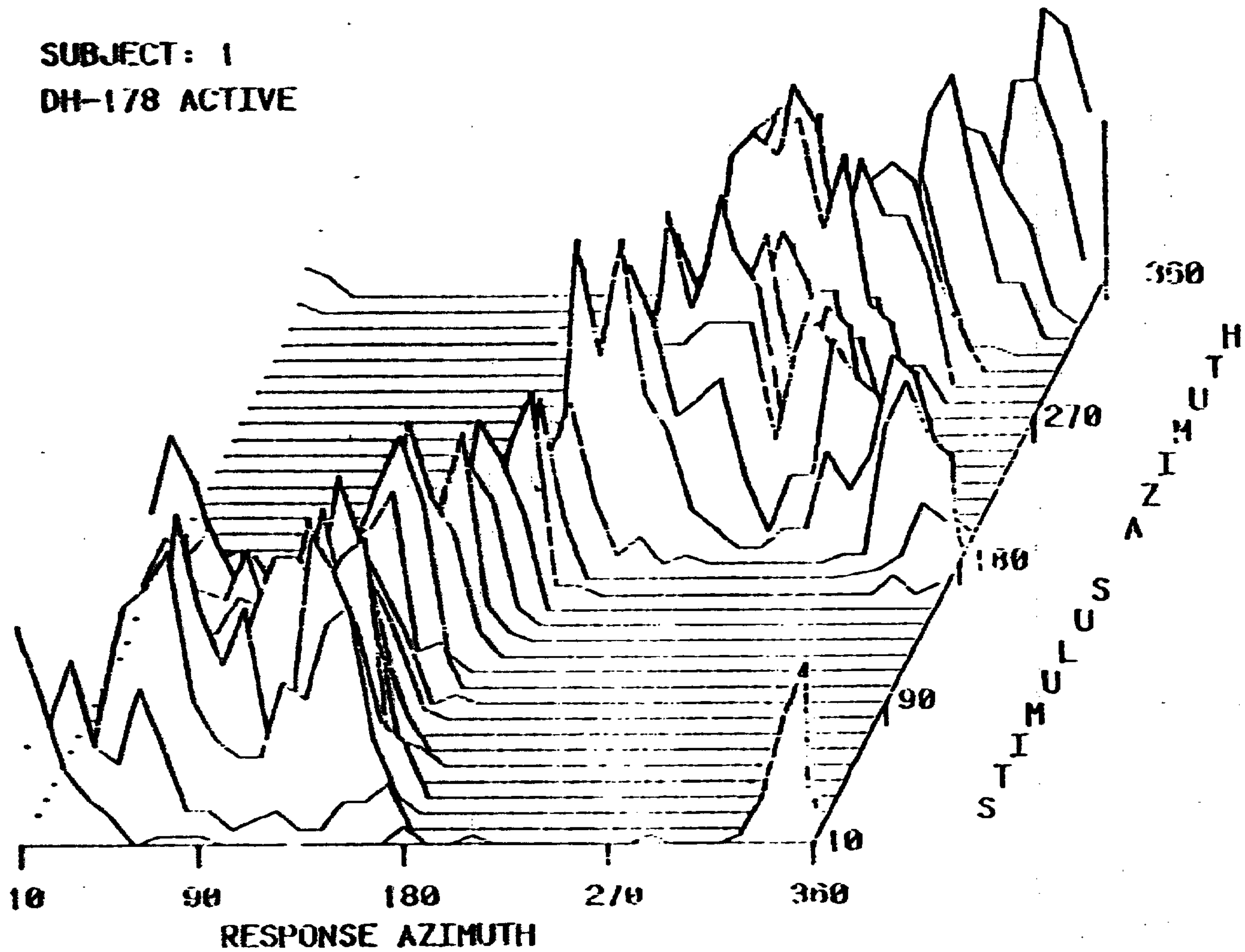
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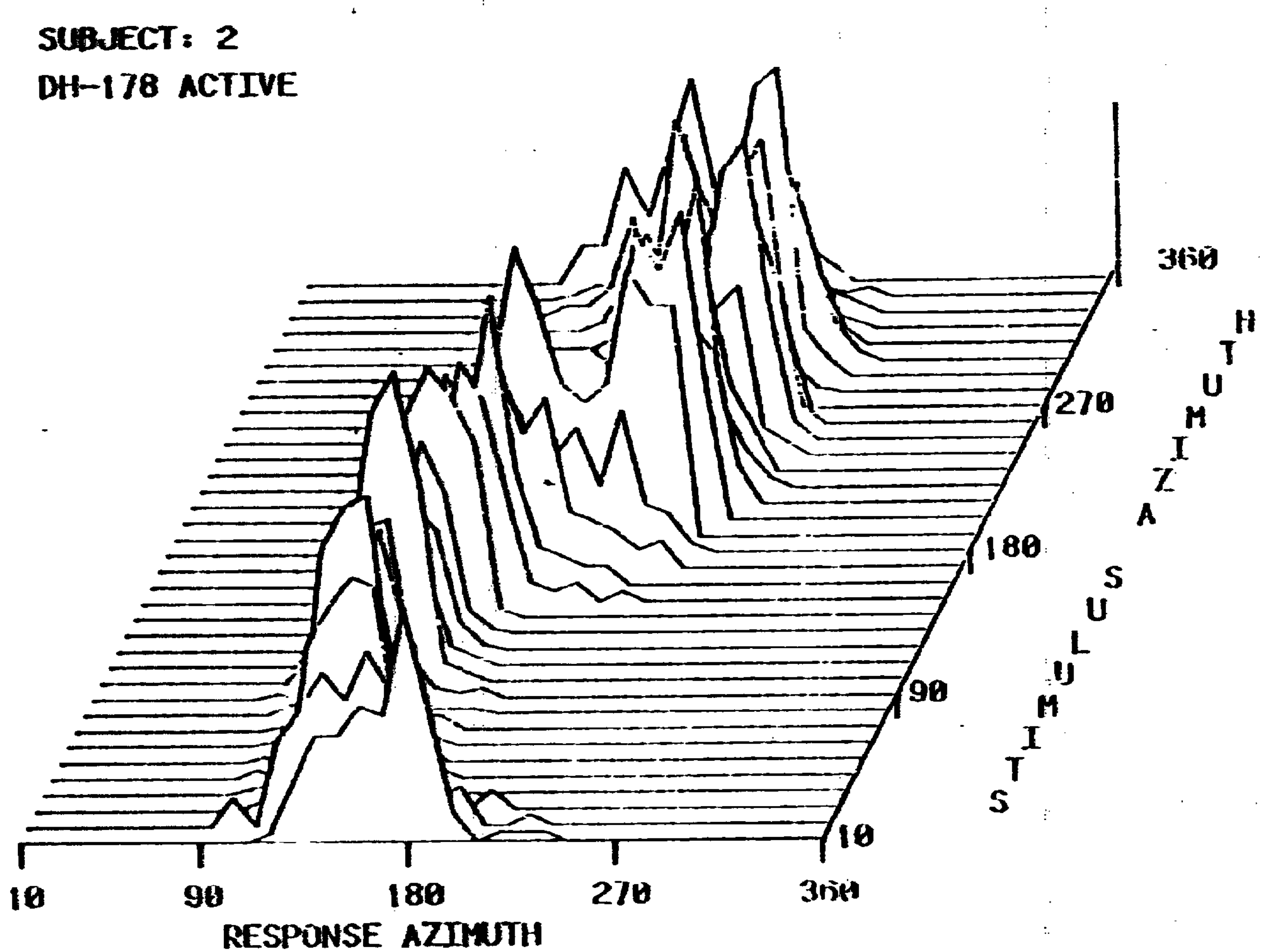
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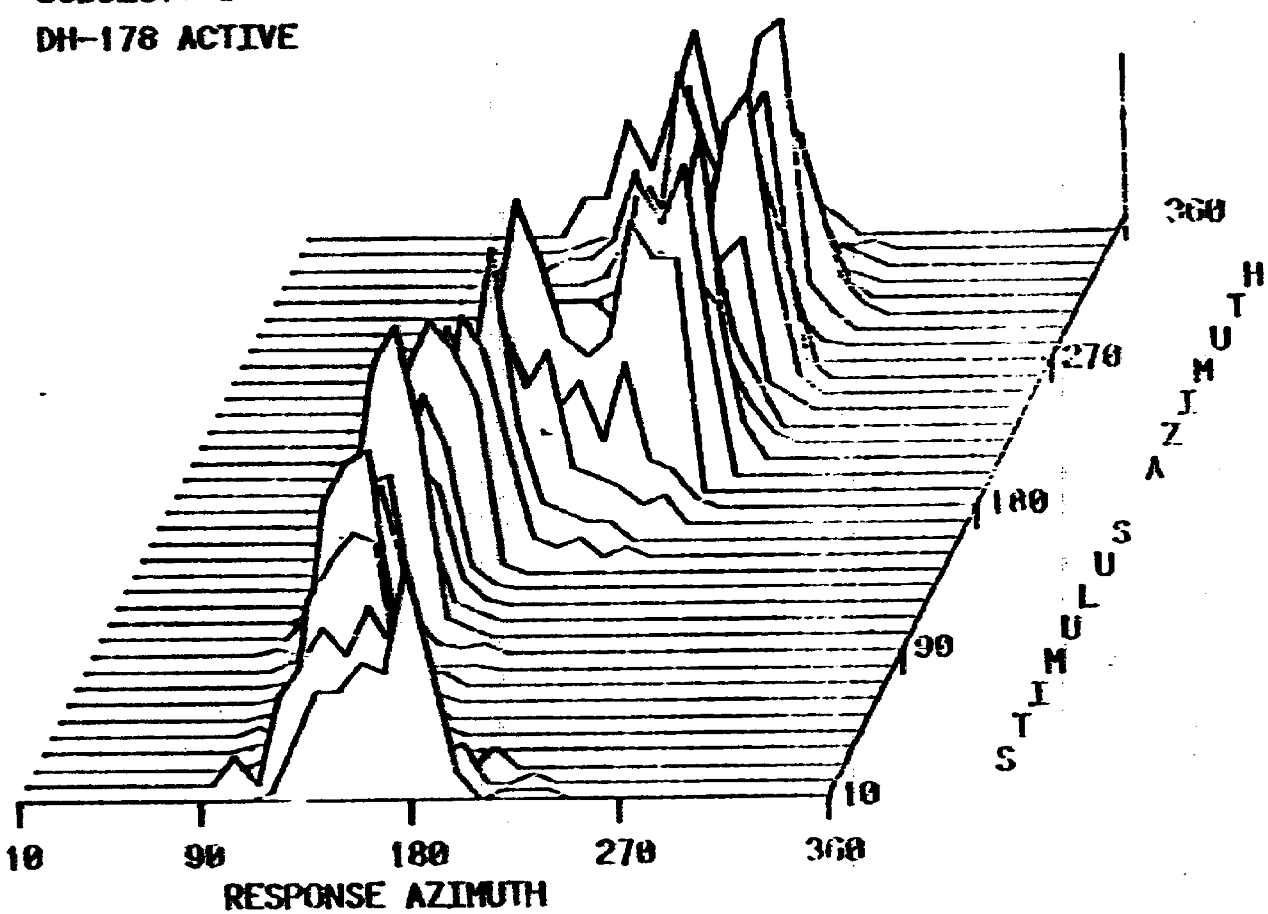

Auditory Localization Employing a Discrimination Task: A Preliminary Report

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TABLE 2. P(c) FOR SUBJECT TWO FOR 8 AZIMUTH POSITIONS PG. 39-40

TABLE 3. P(c) FOR SUBJECT THREE FOR 8 AZIMUTH POSITIONS PG. 41-42

INTRODUCTION

Williams (1978) challenged the idea that recognition criteria should be used in defining auditory spatial responses. Mill (1958) in the definitive study of auditory localization used a recognition procedure to determine what he called minimum audible angle (MAA). In the task the observer had to determine whether a comparison stimuli was left or right of the standard. A modifiea method of constant stimuli was employed and no effort was made to control for response bias. Williams employed a two-alternative forced choice modified up-down procedure to determine auditory location acuity. He was able to use a signal detection model to isolate response bias. The results demonstrated that a same-different response yielded dissimilar results from the Mill's study at 90° azimuth location. Williams labelled his discrimination index minimum discriminable angle (MDA) in order to differentiate from MAA which Williams called recognition threshold. The MDA's were considerably smaller than MAA's for 90° azimuth (8° MDA as compared to 40° MAA).

The present study employed a two alternative forced-choice procedure with a same-different response. Considering problems associated with initial values, a titration method was not included in the present study.

Localization information on identification of a source azimuth was reported in an earlier study (Elfner & Howse, 1984). Absolute identification of a single sound source was found for 36 azimuth positons spaced 10° apart starting from 0° azimuth. The results indicated that identification of source position was consistent across all azimuth points with a spread accuracy of approximately 10°. Since the present study employed a discrimination task of same-different rather than a recognition task one would assume our data in the right front quadrant would be similar to Williams' data. Data gathered in the three other quadrants have no previous data base from signal detection models, hence the information obtained in the left front and rear quadrants is new data. In addition the data was obtained from all quadrants in a pseudo random manner. This technique has also never been employed within the context of a signal detection discrimination task, hence the data is also in a sense new data. The major predictions of auditory discrimination localization are based on data from the identification of azimuth study. One would expect fairly consistent discrimination across azimuth since no significant deviations in localization accuracy were noted in the Elfner and Howse study as a function of azimuth of the source.

Method

Subjects

Three paid volunteers, two females aged 22 and 33 and a male aged 20 served as observers. Two of the subjects had served in previous auditory localization studies. All three subjects had pure tone thresholds within normal limits (ANSI, 1969) at audiometric frequencies and also exhibited hearing threshold at no greater than 20 dB (re 20 uPa) at 10 kHz. Subjects had no known auditory or vestibular pathologies.

Apparatus

Observations were made in an anechoic chamber (Tracoustics Inc) which measured 17 ft by 17 1/2 ft by 23 ft from wedge tip to wedge tip. Acoustic signals were produced by Koss-E-9 electrostatic transducer mounted on a rotatable boom with a radius of 8 ft. The original response manipulandum used in the localization study was employed except that when the pointer was to the left of center a "same" response was given and when the pointer was to the right of center a "different" response was recorded. Head orientation was maintained by visual occlusion of two (LED) images located at disparat points. One LED was located to the left of the subject another LED was located directly in front of the subject. A half-silvered mirror was mounted on a standard pair of glasses in such a manner that superimposition of thw two LED's occurred when the subject's head was pointed straight ahead.

Stimulus generation was similar to the single source localization study with adjustments of intertrial interval to accommodate boom movements and setting times. Movement noise was masked by matched bandpass energy from an overhead speaker (see study one). A layout of the apparatus in the anechoic chamber is shown in Figure 1. of study one.

Procedure

All subjects were given pre-training in the experimental task at all 8 azimuth settings with the 10 comparison stimulus presented at 4° spacing; five clockwise anf five counterclockwise positions from the standard azimuths of 0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315°.

During observation session the anechoic chamber was dark except for the red light from the response manipulandum and the fixation lights. This procedure insured that the boom and transducer wer not visible. Each session consisted of 600 trials with short breaks after each 100 trials. The trial session was self-paced and lasted approximately one hour.

A trial was initiated by the subject pressing a button on the rim fo the response manipulandum. Following a 2 sec. interval a 750 msec burst of noise at 54 dB (re 20 uPa) (see study one) was presented, this was followed by a 750 msec interval (during which the boom traveled to one of the comparison positions or moved away from and back to standard azimuth position) the 750 msec burst of noise was repeated at this position. The subject was then free to adjust the pointer to indicate whether the second burst came from the "same" position or a "different" position than the original burst. A button press initiated the next trial. The primary task of the subject was to respond in a self-paced stimulus discrimination pradigm. The order of presentation of azimuth position, comparison stimulus and false alarm trial were quasi random. A false alarm trial was presented for each comparison trial in a signal detection two alternative forced-choice procedure. Approximately 100 comparison estimates were determined with approximately 100 false alarm trials for each of the ten comparison positions at each of the 8 azimuth positions.

Results

A listing of the obtained results are shown in the tables 1-3. In general the smallest thresholds were found in the 0° azimuth condition and the 180° azimuth condition. The poorest discrimination was in the 135° and the 225° azimuth conditions; that is rearward and lateral. The counter and counterclockwise discriminations were approximately equal.

Discussion

The results of the present study demonstrate similarly to Williams (1978) and to Mills (1958), that discriminative localization is best for straight ahead azimuths. The forward quadrants show fairly accurate localization. The thresholds at 90° azimuth are comparable to those determined by Williams (1978). In general the discrimination performance is weaker in the rear quadrants. However, two subjects did demonstrate fairly accurate discrimination for the 180° azimuth location.

Results from the data in the straight ahead condition seem to indicate that the procedure employed may be responsible for the rather inflated discrimination thresholds. Both Mills (1958) and Williams (1978) found thresholds at 0° azimuth to be 1° or 2°. Our study showed a spread of thresholds of from 4° to 8°. The fact that a masker signal occured between the test and the comparism stimuli could account for this disparity. The subjects invariably found it difficult to maintian the position of the first presented stimulus due to the presentation of the masking signal that followed. The interposition of the masker was required to mask the movement sounds of the apparatus that could have biased the response if left unmasked.

Another reason for the rather large discrimination thresholds is the use of random selection of standard azimuth. By employing both a randmized azimuth and a randomized comparism for the azimuth the task was made considerably more difficult for the subject than in either the Mills (1958) or the Williams (1978) studies. The latter authors gathered all there discrimination data for a single source azimuth before proceeding to another azimuth. The latter technique simplifies the subjects task as he does get repeated presentations of the standard azimuth which could form a relatively stable basis on which to make comparison judgments.

Only one subject demonstrated superior discrimination data over identification in all quadrants. The remaining two except for the zero degree azimuth condition showed thresholds for discrimination that were little if any better than the identification thresholds. Finally, the false alarm rates demonstrated no particular pattern with regard to azimuth however the subject who showed the most acute thresholds also demonstrated by far the lowest false alarm rate. The subject with the largest discrimination thresholds also had the highest false alarm rate.

Two changes would be suggested for further research. One, use up-down procedure to shorten the total task time and to decrease the length of the interveining masking intervals and two, get complete data from a fixed stimulus azimuth rather than employing total randomness as in the present study.

AUDITORY LOCALIZATION: DISCRIMINATION OF AZIMUTH

SUBJECT: 1

STANDARD AZIMUTH: 0

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
10.	0.889	0.32E-01	350.	0.853	0.35E-01
8.	0.814	0.48E-01	352.	0.869	0.34E-01
6.	0.659	0.50E-01	354.	0.627	0.56E-01
4.	0.498	0.56E-01	356.	0.563	0.53E-01
2.	0.527	0.58E-01	358.	0.489	0.63E-01

STANDARD AZIMUTH: 45

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
60.	0.868	0.36E-01	30.	0.896	0.38E-01
57.	0.714	0.49E-01	33.	0.825	0.35E-01
54.	0.685	0.52E-01	36.	0.661	0.49E-01
51.	0.583	0.51E-01	39.	0.559	0.52E-01
48.	0.532	0.60E-01	42.	0.509	0.52E-01

STANDARD AZIMUTH: 90

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
110.	0.949	0.28E-01	70.	0.911	0.38E-01
106.	0.897	0.34E-01	74.	0.735	0.48E-01
102.	0.734	0.41E-01	78.	0.644	0.49E-01
98.	0.742	0.53E-01	82.	0.506	0.63E-01
94.	0.496	0.62E-01	86.	0.511	0.61E-01

STANDARD AZIMUTH: 135

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
150.	0.851	0.41E-01	120.	0.848	0.35E-01
147.	0.718	0.48E-01	123.	0.783	0.49E-01
144.	0.520	0.50E-01	126.	0.680	0.67E-01
141.	0.519	0.49E-01	129.	0.561	0.62E-01
138.	0.529	0.61E-01	132.	0.485	0.53E-01

STANDARD AZIMUTH: 180

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
195.	0.869	0.41E-01	165.	0.857	0.39E-01
192.	0.680	0.56E-01	168.	0.752	0.54E-01
189.	0.604	0.61E-01	171.	0.588	0.68E-01
186.	0.519	0.59E-01	174.	0.521	0.51E-01
183.	0.476	0.58E-01	177.	0.494	0.71E-01

STANDARD AZIMUTH: 225

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
240.	0.890	0.35E-01	210.	0.852	0.37E-01
237.	0.808	0.37E-01	213.	0.728	0.41E-01
234.	0.684	0.52E-01	216.	0.607	0.56E-01
231.	0.591	0.53E-01	219.	0.533	0.51E-01
228.	0.529	0.54E-01	222.	0.497	0.59E-01

STANDARD AZIMUTH: 270

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
285.	0.862	0.38E-01	255.	0.913	0.30E-01
282.	0.669	0.46E-01	258.	0.830	0.41E-01
279.	0.598	0.55E-01	261.	0.669	0.50E-01
276.	0.553	0.58E-01	264.	0.581	0.75E-01
273.	0.512	0.55E-01	267.	0.470	0.52E-01

STANDARD AZIMUTH: 315

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
330.	0.877	0.36E-01	300.	0.876	0.34E-01
327.	0.791	0.51E-01	303.	0.864	0.49E-01
324.	0.674	0.58E-01	306.	0.657	0.51E-01
321.	0.602	0.43E-01	309.	0.602	0.50E-01
318.	0.496	0.61E-01	312.	0.509	0.67E-01

AUDITORY LOCALIZATION: DISCRIMINATION OF AZIMUTH

SUBJECT: 2

STANDARD AZIMUTH: 0

CW COMP AZIM	P(C)	SD	CCW COMP AZIM	P(C)	SD
5.	0.907	0.27E-01	355.	0.900	0.34E-01
4.	0.861	0.42E-01	356.	0.871	0.31E-01
3.	0.723	0.55E-01	357.	0.645	0.46E-01
2.	0.630	0.53E-01	358.	0.586	0.53E-01
1.	0.494	0.60E-01	359.	0.510	0.72E-01

STANDARD AZIMUTH: 45

CW COMP AZIM	P(C)	SD	CCW COMP AZIM	P(C)	SD
55.	0.975	0.17E-01	35.	0.987	0.15E-01
53.	0.933	0.26E-01	37.	0.931	0.25E-01
51.	0.834	0.38E-01	39.	0.834	0.41E-01
49.	0.732	0.42E-01	41.	0.701	0.48E-01
47.	0.568	0.63E-01	43.	0.532	0.50E-01

STANDARD AZIMUTH: 90

CW COMP AZIM	P(C)	SD	CCW COMP AZIM	P(C)	SD
105.	0.909	0.34E-01	75.	0.966	0.23E-01
102.	0.854	0.32E-01	78.	0.966	0.24E-01
99.	0.809	0.35E-01	81.	0.834	0.41E-01
96.	0.707	0.51E-01	84.	0.731	0.49E-01
93.	0.557	0.57E-01	87.	0.575	0.64E-01

STANDARD AZIMUTH: 135

CW COMP AZIM	P(C)	SD	CCW COMP AZIM	P(C)	SD
150.	0.980	0.17E-01	120.	0.958	0.21E-01
147.	0.863	0.34E-01	123.	0.895	0.35E-01
144.	0.774	0.43E-01	126.	0.839	0.49E-01
141.	0.705	0.43E-01	129.	0.657	0.69E-01
138.	0.523	0.66E-01	132.	0.533	0.47E-01

STANDARD AZIMUTH: 180

CW			CCW		
COMP AZIM	P(C)	SD	COMP AZIM	P(C)	SD
190.	0.976	0.19E-01	170.	0.964	0.26E-01
188.	0.921	0.30E-01	172.	0.948	0.23E-01
186.	0.809	0.52E-01	174.	0.866	0.41E-01
184.	0.635	0.61E-01	176.	0.773	0.46E-01
182.	0.530	0.51E-01	178.	0.548	0.63E-01

STANDARD AZIMUTH: 225

CW			CCW		
COMP AZIM	P(C)	SD	COMP AZIM	P(C)	SD
240.	0.976	0.22E-01	210.	0.981	0.15E-01
237.	0.947	0.23E-01	213.	0.887	0.28E-01
234.	0.837	0.39E-01	216.	0.823	0.46E-01
231.	0.648	0.52E-01	219.	0.675	0.49E-01
228.	0.560	0.60E-01	222.	0.546	0.85E-01

STANDARD AZIMUTH: 270

CW			CCW		
COMP AZIM	P(C)	SD	COMP AZIM	P(C)	SD
285.	0.986	0.13E-01	255.	0.993	0.91E-02
282.	0.963	0.18E-01	258.	0.859	0.37E-01
279.	0.834	0.41E-01	261.	0.803	0.43E-01
276.	0.628	0.56E-01	264.	0.637	0.56E-01
273.	0.526	0.57E-01	267.	0.539	0.50E-01

STANDARD AZIMUTH: 315

CW			CCW		
COMP AZIM	P(C)	SD	COMP AZIM	P(C)	SD
325.	0.967	0.17E-01	305.	0.928	0.23E-01
323.	0.915	0.31E-01	307.	0.887	0.36E-01
321.	0.838	0.43E-01	309.	0.821	0.33E-01
319.	0.605	0.40E-01	311.	0.642	0.55E-01
317.	0.537	0.52E-01	313.	0.518	0.60E-01

AUDITORY LOCALIZATION: DISCRIMINATION OF AZIMUTH

SUBJECT: 3

STANDARD AZIMUTH: 0

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
10.	0.862	0.35E-01	350.	0.883	0.34E-01
8.	0.861	0.36E-01	352.	0.874	0.33E-01
6.	0.781	0.41E-01	354.	0.944	0.29E-01
4.	0.655	0.50E-01	356.	0.689	0.49E-01
2.	0.561	0.52E-01	358.	0.611	0.53E-01

STANDARD AZIMUTH: 45

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
60.	0.836	0.39E-01	30.	0.809	0.41E-01
57.	0.686	0.49E-01	33.	0.786	0.43E-01
54.	0.748	0.46E-01	36.	0.681	0.49E-01
51.	0.609	0.51E-01	39.	0.627	0.44E-01
48.	0.590	0.59E-01	42.	0.584	0.51E-01

STANDARD AZIMUTH: 90

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
110.	0.805	0.42E-01	70.	0.782	0.43E-01
106.	0.681	0.49E-01	74.	0.738	0.46E-01
102.	0.648	0.45E-01	78.	0.606	0.47E-01
98.	0.641	0.51E-01	82.	0.577	0.52E-01
94.	0.488	0.53E-01	86.	0.549	0.52E-01

STANDARD AZIMUTH: 135

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
155.	0.818	0.41E-01	115.	0.796	0.38E-01
151.	0.768	0.45E-01	119.	0.712	0.48E-01
147.	0.662	0.50E-01	123.	0.684	0.49E-01
143.	0.584	0.43E-01	127.	0.589	0.52E-01
139.	0.523	0.53E-01	131.	0.557	0.43E-01

STANDARD AZIMUTH: 180

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
195.	0.810	0.45E-01	165.	0.807	0.48E-01
192.	0.736	0.49E-01	168.	0.718	0.49E-01
189.	0.646	0.60E-01	171.	0.696	0.48E-01
186.	0.653	0.55E-01	174.	0.630	0.51E-01
183.	0.537	0.48E-01	177.	0.494	0.55E-01

STANDARD AZIMUTH: 225

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
245.	0.803	0.44E-01	205.	0.804	0.42E-01
241.	0.735	0.41E-01	209.	0.741	0.36E-01
237.	0.674	0.47E-01	213.	0.676	0.49E-01
233.	0.559	0.52E-01	217.	0.566	0.52E-01
229.	0.554	0.52E-01	221.	0.543	0.53E-01

STANDARD AZIMUTH: 270

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
285.	0.851	0.37E-01	255.	0.762	0.45E-01
282.	0.790	0.43E-01	258.	0.651	0.50E-01
279.	0.601	0.52E-01	261.	0.651	0.50E-01
276.	0.649	0.53E-01	264.	0.575	0.60E-01
273.	0.518	0.53E-01	267.	0.574	0.52E-01

STANDARD AZIMUTH: 315

CW COMP AZIM	CW P(C)	CW SD	CCW COMP AZIM	CCW P(C)	CCW SD
325.	0.837	0.39E-01	305.	0.871	0.35E-01
323.	0.664	0.52E-01	307.	0.754	0.45E-01
321.	0.605	0.54E-01	309.	0.648	0.48E-01
319.	0.597	0.48E-01	311.	0.534	0.55E-01
317.	0.537	0.53E-01	313.	0.537	0.53E-01

STOP --

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